Evaluation of traffic emission models coupled with a microscopic traffic simulator and on-road measures

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***Abstract*—This study aims to compare and contrast the emission results of two instantaneous traffic emission models coupled with a microscopic traffic simulator and COPERT. These will be evaluated with the observed results of on-road measurements done by RSD (Remote Sensing Device) on real driving vehicles in Barcelona. This is done by the comparison of the traffic emission model Panis 2006 which is already integrated into the traffic simulator AIMSUN, and the coupling of AIMSUN to an up to date vehicle emission model, PHEMlight. The studys goal is to assess the divergence between the observed results of the RSD measurements performed at street level, and the modelled emission results in order to evaluate the representativeness of the emission factors applied.**

***Keywords*—Air quality, vehicle emissions, modeling.**

I. Extended Abstract

Air pollution is an important issue for public health, economy and environment. Barcelona is one of the most polluted cities in Europe, and this is directly related with the urban traffic. According to that, air quality measures are everyday more connected with mobility measures (e.g. vehicle restriction, car lanes reduction, increment of parking fees) that aim for the reduction of moving vehicles within the city and the pollution associated to them. To further evaluate and assess the utility of these measures, the coupling of vehicle emission models with traffic simulators have proved to increase the accuracy of emissions [1] but the emission factors used must be as realistic as possible and calibrated to the city and conditions where they are applied. Considering this, the present study compares the NOx (NO2 + NO) emission results of: (I) Panis 2006 [2], (II) PHEMlight [3], (III) the standardized average speed model COPERT IV v10.0 [4] and (IV) COPERT V [5]. Additionally, they were evaluated with observed results of on-road measurements performed with RSD on real driving vehicles in Barcelona [6].

A. Objective

This works goal is to do a primary assessment of the performance of different vehicle emission models by its comparison with observed emission results in Barcelona to be then applied into the air quality integrated system developed during the Ph.D thesis of the author.

B. Methodology

The traffic simulator AIMSUN [7] was used to obtain the representative driving cycle (speed-time data) of a passenger car (PC). The different origin-destination demand matrices needed by AIMSUN as well as the Barcelona network were provided by inLab FIB research centre. The driving cycle of the vehicle studied was introduced into PHEMlight vehicle emission model to obtain its NOx emissions during the whole cycle. These are represented for every time-step of 1.5 seconds in g/h and initially compared to the already coupled but outdated emission model within AIMSUN: Panis 06, and the COPERT IV and COPERT V average speed emission model. Since COPERT works with the cycle average speed, this was set to 28 km/h according to the average speed of the RSD campaign, which was of 28.6 km/h, and to the drive cycle used, whose average speed was of 26.7 km/h. In addition, vehicle degradation factors were applied to COPERT V petrol emission factors according to the vehicle age as stated by EMEP/EEA.

C. Results

The first to notice when looking at the results is the different approach between the instantaneous models (PHEMlight and Panis 06) and COPERT (see Figure 1). While the last calculates the average emissions for the whole cycle, PHEMlight and Panis 06 represent the emission peaks occurred during acceleration periods.

Regarding the average emissions for the whole cycle compared with the RSD observations, there are large differences between petrol and diesel simulated results (see Figure 2). In general, results for diesel are closer to observations for all models, with the largest discrepancies observed in PHEMlight for Euro 5, with an overestimation of 33%, or Panis 06 for Euro 6 vehicles, with an overestimation of 52%. COPERT V agrees well with observations, worth to notice here the difference with

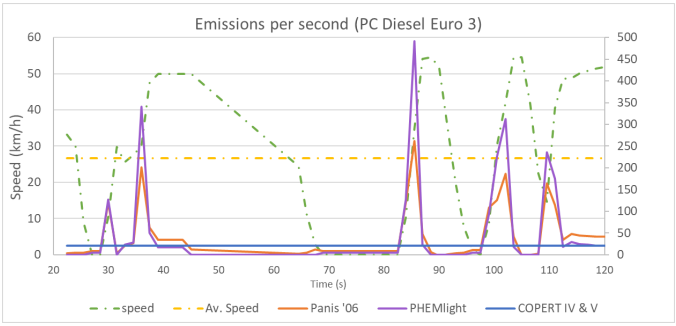

Fig. 1. Speed (km/h) and NOx emissions (g/h) of a passenger car (PC) along time with Panis 06, PHEMlight and COPERT IV and V.

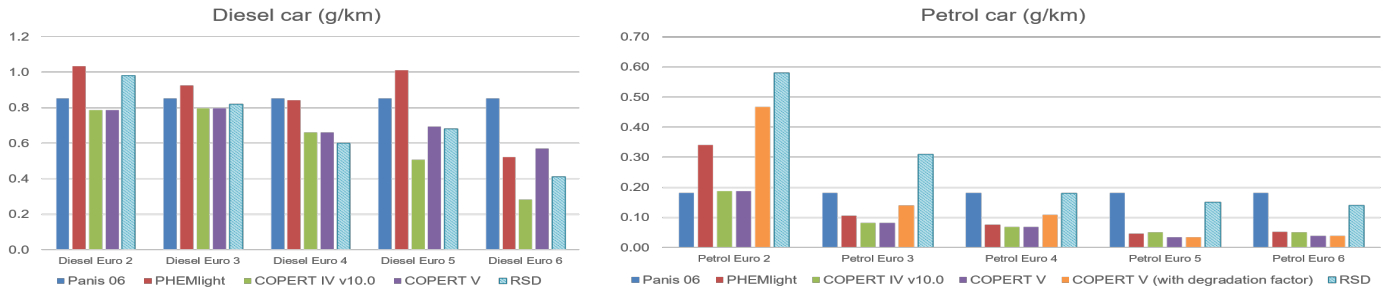

Fig. 2. NOx emissions (g/km) from petrol (left) and diesel (right) estimated by Panis 06, PHEMlight, COPERT IV and V models and the observed average of the RSD study for Euro categories from Euro 2 to Euro 6. Euro vehicles.

COPERT IV for Euro 5 and Euro 6, which underestimates by 34% and 44% respectively.

On the other hand, results for petrol differ more from observations, with large underestimations from all models. In this case the degradation factor applied in COPERT V corrects its results. Applying it, COPERT V underestimates by a factor of 1.2, 2.2 and 1.7 for Euro 2, 3 and 4 respectively. This increases to 3.1, 3.8 and 2.7 without them. For Euro 5 and 6 only Panis 06 agrees with observations, while the rest underestimates by factors of around 4.4 and 3.6.

D. Discussion

Firstly it is noticeable the difference in acceleration peaks that average speed models like COPERT cannot catch. Since for this particular comparison observations were based also on an average speed value, COPERT emission estimations agree reasonably well. Regarding the emissions simulated, diesel values of all models studied agree well with observations, worth to notice the improvement from COPERT IV to COPERT V for Euro 5 and 6 models. However, for petrol there is a large underestimation from all models, with the exception of Panis 06 on Euro 4, 5 and 6. It is outstanding that Panis 06, being such an old model and with its emission factors considering only until Euro 3, agrees so well with the newer petrol vehicle categories, while it largely underestimated the previous ones. It is also worth to stand out the improvement in emission results of the application of vehicle degradation factors to COPERT V.

However, a further study should be made considering observations of instantaneous speed emissions, and not average results, once the data will be available. It is expected then for instantaneous emission models to obtain more accurate results than COPERT V.

II. Acknowledgment

Daniel R. Rey acknowledges the Ministerio de Economa, Industria y Competitividad of Spain for the FPI research grant BES-2016-078116 and RACC institution for the data provided.

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Daniel Rodrguez holds a MSc in Air Pollution Management and Control by the University of Birmingham, and a BSc degree in Chemical Engineering by the UPC. Currently he is doing a Ph.D in Environmental Engineering with Marc Guevara, Albert Soret (from BSC-ES) and Mł Paz Linares (from inLab) in the evaluation of the impact of mobility policies in Barcelonas air quality by the development of an integrated model.